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(54) **Checking for surface flaws**

(57) An improvement is disclosed in methods for checking a metallic workpiece for surface flaws by high frequency heating and infra-red scanning, the workpiece being moistened prior to scanning with an infrared emission pyrometer.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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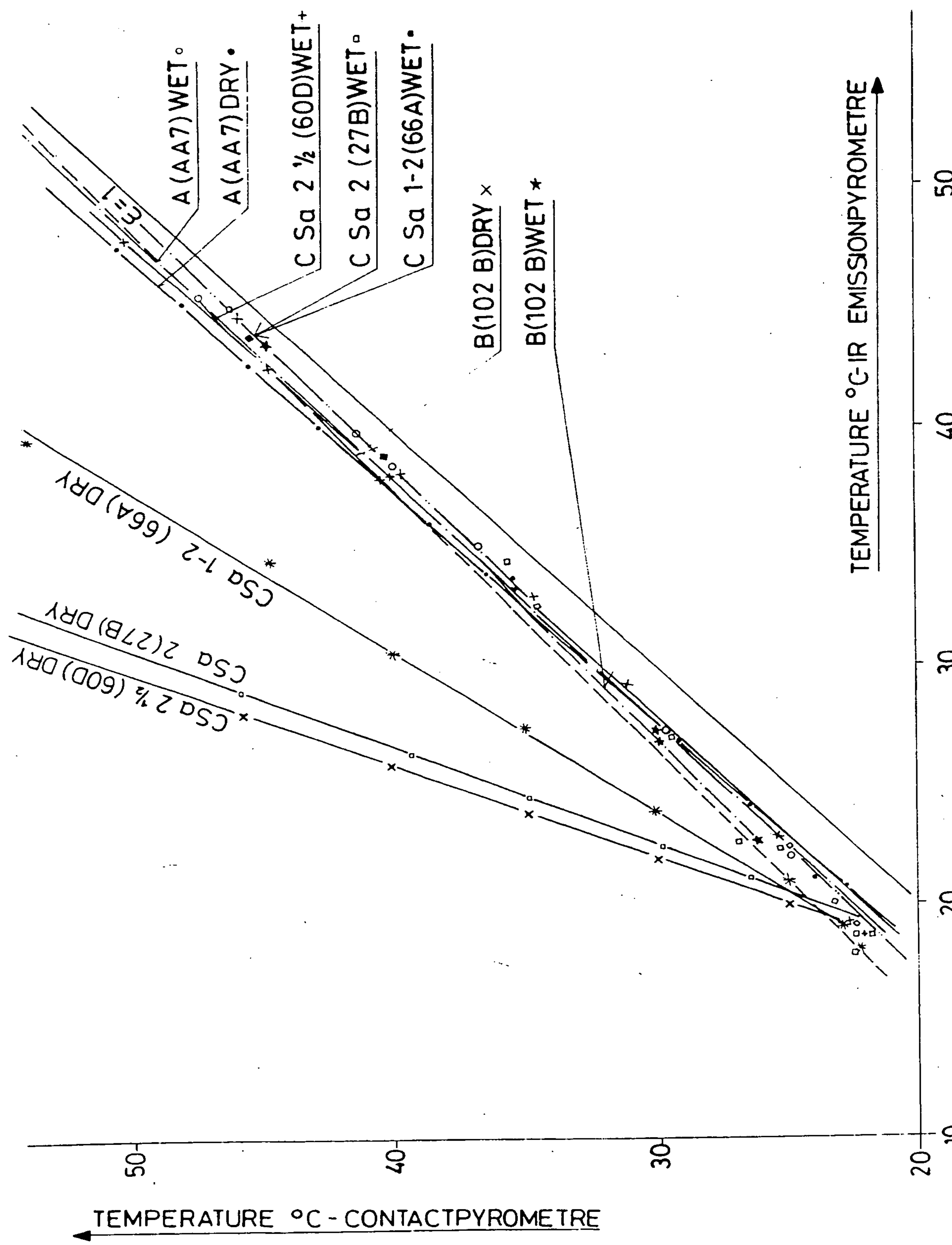

A (AA7) WET ○
A (AA7) DRY •
C Sa 2 ½ (60D) WET +
C Sa 2 (27B) WET □
C Sa 1-2 (66A) WET •
B (102 B) DRY ×
B (102 B) WET ★
ε=1
CSa 1-2 (66A) DRY
CSa 2 (27B) DRY
CSa 2 ½ (60D) DRY
TEMPERATURE °C-IR EMISSIONPYROMETRE
TEMPERATURE °C - CONTACTPYROMETRE
10
20
30
40
50
20
30
40
50

SPECIFICATION

Checking for surface flaws

This invention relates to a method for checking a workpiece such as a metallic billet for surface flaws such as cracks. It is desirable to detect surface flaws in workpieces at an early stage of production so that they may be removed, for example by grinding, so that flaws will not follow the workpiece into further production stages to finished products.

It is known that surface flaws such as cracks in metal workpieces can be detected by heating the surface of the workpiece by means of high frequency current while the workpieces is brought to pass, usually in its longitudinal direction, through a high frequency induction coil, the workpiece surface immediately being scanned, for example by infra-red emission pyrometers, for recording the temperature distribution across the workpiece surface. The temperature distribution across a typical workpiece surface is recorded and shown as a streaked pattern, surface flaws such as cracks being revealed in the pattern as a result of change of temperature profile adjacent flaws such as cracks. As the workpiece is scanned repeatedly a combination picture can be developed showing, for example in relation to a crack, a temperature ridge.

The surface condition of the workpiece, and consequently the thermal emission characteristics of the surface can vary over a surface to be checked and indeed very between different workpieces. One factor in surface condition and emission characteristic variations is corrosion and indeed treatment to remove corrosion. Another is mill scale.

Varying degrees of corrosion and/or mill scale across a workpiece surface with consequent variations in emission characteristics can give widely varying local signal/disturbance ratios and make flaw detection more difficult particularly for very shallow flaws e.g. less than 1mm deep. Workpieces can be shot blasted to reduce or remove corrosion, mill scale etc., but the reduction of detected surface temperatures and surface temperature changes at flaws which results can again make shallow flaw detection more difficult. Moreover where both shot blasted and corroded/scaled workpieces are to be checked on the same apparatus recalibration may be required in between.

It is an object of the present invention to provide an improved method whereby any or all of these disadvantages are removed or at least mitigated.

No wire cable or electrolyte

According to the present invention a method of checking a workpiece for surface flaws involves heating the workpiece, the surface to be checked being moistened with sufficient liquid to alter the emission coefficient and the moistened surface being scanned by an infra-red emission pyrometer.

The term "workpiece" includes metal billets, pieces rolled for the first time, pieces having been subjected to further rolling treatment and finished products, all being as bars, pipes, profiles and indeed any other usually encountered shape.

The moistening of the surface to be checked may be with an aqueous liquid such as water. The liquid used may have an added component or components to reduce surface tension and/or freezing point. The liquid is preferably applied in an amount sufficient substantially to equalise the average emission coefficient of the surface with that of other surfaces or workpieces of varying finish treated in a like matter.

Scanning by infra-red emission pyrometers gives a temperature picture deviating from the real temperature picture of the surface (as for example when scanned by a contact pyrometer) because of the emission coefficient of the surface. The emission coefficient depends on the nature of the surface and usually varies between 0 and 1. Rolled workpieces with mill scale usually have an emission coefficient of between 0.90 and 0.95. Where shot blasting of the surface to be checked is employed as a means of reducing the local disturbances caused for example by mill scale, this results in an undesired side effect of the surface becoming bright and a substantial alteration of its emission properties. An IR emission pyrometer would as a consequence give surface temperature readings which are too low and likewise record too low a temperature in the flaws or cracks. Where no shot blasting is employed or lesser degrees of shot blasting are employed on workpieces for example having mill scale, the variations of emission coefficient over the surface of the workpiece can result in different and possibly incorrect interpretation of the depth of flaws detected. Moreover as indicated above recalibration can be required between detection operations on shot blasted and non-shot blasted workpieces, this operation being complicated, requiring much time and therefore not being appropriate to an industrial operation. By the present invention we have however found that the emission coefficient for all types of appropriate workpiece surfaces can be made approximately

water

equal by moistening of the surfaces with an appropriate liquid, for example water to which has been added components to modify surface tension and/or freezing point. The addition of components to decrease surface tension to give a better moistening effect is a preferred feature of the invention. Likewise where checking of workpieces at temperature below 0°C needs to be done addition of components to depress the freezing point of the liquid may be required. Experiments have shown that by such moistening of the surface of the workpiece to be checked, approximately the same emission coefficient results in most cases independent of the degree of pre-treatment of the workpiece, the emission coefficient deviating only to a small degree from that of a dry workpiece with mill scale. The variation in emission coefficient for moistened workpieces is generally so small that it has no practical importance for the method of the invention. Less disturbances in the temperature picture result both in local terms for a given workpiece and between one workpiece and another due to the overall equalisation of emission coefficient and there are also obtained

important improvements of the signal/disturbance ratio. This is particularly important for shot blasted or similarly treated workpieces where, as stated above, the signal/disturbance ratio can be so low that detection of very shallow cracks can fail.

The table set out below gives temperature measurements on different types of workpiece surfaces, dry and wet/moistened, using a contact pyrometer (T) and an IR emission pyrometer (IR).

A (AA7 B)				B (102 B)				CSa 1-2 (66A)			
Dry		Wet		Dry		Wet		Dry		Wet	
T	IR	T	IR	T	IR	T	IR	T	IR	T	IR
23.9	21.0	22.4	19.0	24.1	20.0	22.3	18.0	22.7	19.5	21.9	18.5
25.8	23.0	24.7	22.0	25.4	21.5	26.1	22.5	25.1	21.0	25.3	22.5
30.7	28.5	29.7	27.5	30.1	27.0	30.2	27.5	30.1	24.0	30.0	27.5
35.6	34.0	36.7	35.0	35.5	33.5	35.6	33.5	35.0	27.5	34.5	32.5
40.4	38.0	41.3	40.0	40.1	38.0	40.0	38.5	40.0	30.5	40.0	38.5
47.7	45.0	47.2	45.5	46.0	45.0	44.6	43.5	44.3	34.5	45.3	44.0
50.0	47.0			50.1	48.0						

CSa2 (27 B)				CSa 2½ (60 B)			
Dry		Wet		Dry		Wet	
T	IR	T	IR	T	IR	T	IR
23.4	20.0	22.3	18.5	22.4	19.0	22.0	18.5
26.6	21.0	25.0	22.5	24.9	20.0	25.4	23.0
29.8	22.5	29.7	27.5	30.0	22.0	31.4	29.5
34.8	24.5	35.8	34.5	35.0	24.0	34.7	33.0
39.4	26.5	40.0	38.5	40.0	26.0	40.0	38.0
45.7	29.0	46.0	45.0	45.8	28.0	44.7	42.5

Sample A is a metallic workpiece bearing mill scale. Sample B is a metallic workpiece with corroded (rusted) surface and Samples marked CSal-2, CSa2 and CSa2½ had been cleaned by shot blasting, the surfaces being defined in accordance with Swedish standard SIS 055900-1967.

Referring first to the "dry" columns it will be seen that there is an important difference between the two measurements in each case i.e. between the contact pyrometer measurement and the infra-red emission pyrometer measurement which difference increases with the degree of shot blasting - i.e. the difference increases with increasing brightness of the workpiece. As a result of this the readings given by an IR emission pyrometer on shot blasted workpieces can be too low and as a consequence give a proportionately lower increase around a fault. The large difference between infra-red emission readings for the workpieces results as indicated above in the need for substantial recalibration between say a corroded/scaled workpiece and a workpiece which has been shot blasted. The reduction in the temperature peaks at flaws or cracks for shotblasted surfaces changes the tolerances required of the detection apparatus and also produces a reduced signal/disturbance ratio.

Turning now to the figures given in the table for the "wet" tests i.e. with the workpieces moistened in accordance with the present invention, the emission coefficients appear to have been made approximately equal for the various surfaces by virtue of the moistening. By the term "approximately equal" is meant that the emission coefficients of the workpiece surfaces are within a range which can be accepted for the results of the detection/checking method. The workpiece can be moistened before it passes through the induction coil and the moistening liquid is preferably supplied as uniformly as possible to the surface either through a nozzle slot or similar arrangement or simply by letting it flow down along the surface.

The results of the measurements given in the above table for both dry and wet surfaces are shown grapically in the drawing. Here it will be seen that the emission coefficient for the moistened surfaces are all on approximately the same level as for a dry workpiece. It is further to be noted that by moistening all the surfaces have approximately the same emission coefficient and are positioned quite close to the theoretical maximum emission coefficient which is one.

This brings even for highly polished shot blasted surfaces the signal/disturbance ratio to an acceptable level whereby even the very shallowest of surface flaws such as cracks become detectable more easily.

CLAIMS

1. A method of checking a workpiece for surface flaws in which the workpiece is heated, the surface to be checked is moistened with sufficient liquid to alter the emission coefficient thereof and the moistened surface scanned by an infra-red emission pyrometer.

2. A method as claimed in Claim 1 in which the workpiece is heated by means of high frequency current while the workpiece is brought to pass through a high frequency induction coil.

3. A method as claimed in Claim 1 or Claim 2 in which the surface to be checked is moistened with an aqueous liquid.

4. A method as claimed in Claim 3 in which the aqueous liquid is water.

5. A method as claimed in any of the preceding claims in which the surface to be checked is moistened with a liquid having an added component to reduce its surface tension.

6. A method as claimed in any of the preceding claims in which the surface to be checked is moistened with a liquid having an added component to depress its freezing point.

7. A method as claimed in any of the preceding claims wherein the surface to be checked is moistened with sufficient liquid substantially to equalise the average emission coefficient of the surface with that of other surfaces or workpieces of varying finish treated in a like manner.

8. A method of checking a workpiece for surface flaws as claimed in Claim 1 and substantially as described herein.

will electrolyte reduce surface tension

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